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SMALL SATELLITE MARS AEROCAPTURE THROUGH MULTI-EVENT DRAG MODULATION

Abstract

The growing interest in the study of Mars is driving the development of technologies to ease the landing of scientific payloads or the insertion of probes into stable orbits around the red planet. In this context, current exploration capabilities can be enhanced by the use of small satellites as low-cost platforms to carry out dedicated automatic missions. In planetary exploration, aerocapture is considered a promising technique to overcome the challenges brought by specific volume and mass ratio constraints on the design of the propulsion system. Aerocapture is an aero-assisted orbital maneuver in which the vehicle is transferred from a hyperbolic arrival trajectory to an elliptical orbit around the planet by the braking effect of atmospheric drag in a single atmospheric passage. Despite its inherent propellant and mass savings, this orbit insertion technique has never been implemented because of environmental and vehicle-related uncertainties, such as our limited knowledge of the local atmospheric density and/or the lack of real-time navigation data. However, recent studies have pointed out the high technological readiness of aerocapture at Mars, ensured by the vast body of information brought by the many missions that have carried out atmospheric entry. This contribution studies the problem of aerocapture at Mars and focuses on the maneuver feasibility from a purely dynamical point of view, taking into account all the associated uncertainties. Specifically, a multi-event aerocapture optimization strategy is developed and applied to a small satellite equipped with a deployable drag device, whose aperture can be modulated during the atmospheric pass. Firstly, a parametric analysis is carried out to identify the most suitable entry corridors to successfully execute aerocapture in terms of number of events and interplanetary arrival conditions. Then, for some selected scenarios, the optimized drag-modulation strategy is determined to meet specific requirements set by the subsequent pericenter raising maneuver. Finally, the results of this multi-event optimization methodology are compared with the outcome of fixed-aperture and single-event drag modulation strategies to assess the benefits of the technique in terms of number of possible solutions. This study is conducted in the framework of the Small Mission to MarS (SMS), a small orbiter-lander project implementing a deployable drag device.